Incorporating Solar PV and Electric Vehicles into Electric Company Resource Planning

Technical Brief — *Resource Planning for Electric Power Systems (Program 178), PDU Integrated Grid and Energy Systems, Energy Systems and Climate Analysis Group (ESCA)*

Abstract

Improved forecasting of the adoption of Distributed Energy Resources (DERs) by end-use consumers can help power system planners account for the impacts of DERs on the planned system resource mix. This Technical Brief summarizes research on current practices used to forecast Electric Vehicles (EV) and distributed Solar Photovoltaic (PV) adoption and a quantitative analysis of the impact of EV adoption on expected future capacity expansion. Survey results show EV and PV adoption forecasts often are treated as exogenous inputs or modifiers to the main load forecast in resource planning. Granular (hourly, locational) forecasts of the impacts of solar PV and EVs on system load mostly are used for long-term distribution planning purposes. Our quantitative analyses show that EV adoption can significantly impact system planning decisions within a typical planning time horizon, particularly additional renewable resource capacity. Modeling results are highly dependent on specific system conditions, particularly the generation mix, load shapes, and the use of managed charging.

Keywords:

- Distributed energy resources
- Electric Vehicle Adoption
- Rooftop Solar PV Adoption
- Load Impacts of DERs
- Integrated Resource Planning
- Capacity Expansion

Introduction

Development of robust and accurate system load forecasts typically is the starting point for an electric power company's resource planning process. Distributed Energy Resources (DERs) can alter both the magnitude and profile of the expected future system load. Improved forecasting of DER adoption could help system planners to better account for the potential impact of DERs on the future load and system resource mix.

This Technical Brief summarizes ongoing EPRI research and modeling to explore methods to integrate DERs into resource planning. The goals of the EPRI research described here were to: (i) Identify and explain different analytic methods currently used by electric companies to forecast the end-use electric load impacts from consumer adoption and deployment of rooftop Solar Photovoltaic (PV) and Electric Vehicles (EV); and, (ii) Conduct quantitative modeling to illustrate how different EV adoption forecasting scenarios and magnitudes potentially can impact electric company investment decisions.

Part 1: Survey of EV and PV Forecasting Methods

We conducted an extensive literature review to identify methods most commonly used by electric companies to forecast EV and PV adoption. This review included studies developed by national labs, electric companies, industry research organizations, consultants, and academics. In total, we reviewed more than 60 studies that focused on methods to develop EV and PV forecasts, and which included electric company published integrated resource plans (IRPs).

Summary of Literature Review

1. ***It is important to understand the trade-offs associated with using different EV and PV forecasting methods before deciding which method(s) to use.*** Our review revealed there are six widely used approaches to forecast future EVs and PVs deployment: (i) Policy/Goal Driven Adoption; (ii) Extrapolation/Time Series Method; (iii) Stated Preference Models; (iv) Bass-Diffusion Model; (v) Econometric Modeling; and (iv) Payback-based Adoption. Each method has advantages and disadvantages; we recommend system planners to carefully consider these trade-offs before selecting one or more forecasting methods.

2. ***There is no consensus among electric companies on how to forecast EV and PV adoption, although trends emerged in our review.*** Some forecasting methods have been used more often than others. The most popular approach to forecast rooftop PV adoption was Bass-diffusion modeling, which offers a straightforward methodology that can be linked to the economics of the technology. Policy/goal-driven adoption was the most widely used approach to forecast EV adoption, which avoids the need to conduct complex modeling in regional where there may be low current penetration. This approach, however, does not provide direct insights into the relative factors that contribute to adoption, and does not consider the feasibility of achieving the policy targets.

3. ***Most IRPs integrate rooftop PV and EV forecasts as modifiers to their main load forecast.*** Rooftop PV and EV adoption often are forecast separately and treated as exogenous inputs and modifiers to the main load forecast. Resource optimization is then carried out using the new modified "net load" forecast. More granular (hourly, locational) forecasts of solar PV and EV adoption mostly are used for long-term distribution planning, if they are used at all.

4. ***The sophistication of the PV and EV forecasting methods used by electric companies increases with increased penetration of these technologies.*** This is a function of increased data availability that can be used in forecasting models, and the increased importance of capturing the potential future impact of these DERs on the power system.

Part 2: Quantitative Assessment of the Impact of EV Adoption on Resource Plans

To illustrate the important role of DER adoption forecasting in resource planning, we quantitatively analyzed the impact that various EV adoption forecasts could have on the future capacity expansion plan for a hypothetical, nationally representative electric system. Based on a review of a broad range of EV adoption forecasts, we analyzed a Mid Case which assumed 17% of new vehicle sales are EVs by 2030 (6% of all cars on the road), and a High Case which assumed 37% of new cars are EVs by 2030 (14% of all cars on the road). Initially, we assumed EV charging profiles to be "unmanaged," and based these profiles on analysis done by NREL. [1]

The coincidence of unmanaged EV charging load with system peak demand resulted in a projected need for a significant level of new capacity additions as shown in Figure 1.

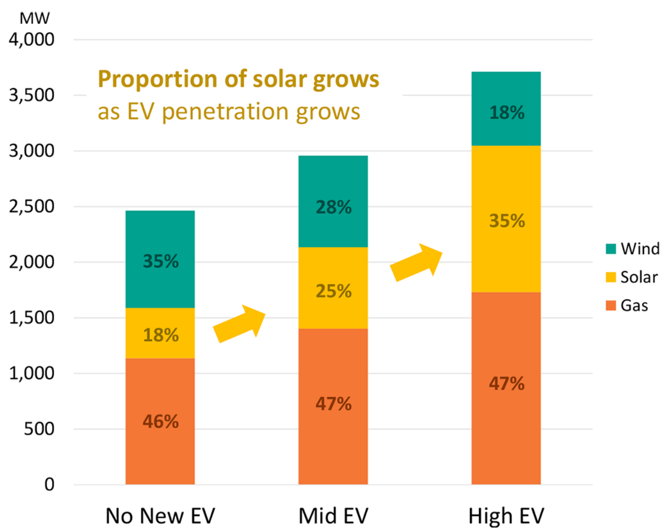

Figure 1: New Capacity Additions (2018-2030)

Note: The figure illustrates the added capacity of wind, solar, and natural gas generation technologies for different scenarios of assumed EV adoption ranging from no new EV to High EV adoption.

Furthermore, our results also show that in the High EV case, the projected future total system capacity grows 6% simply due to EV adoption.

The composition of this new capacity also changes as EV adoption increases. For the electric system we modeled, the amount of projected new utility-scale solar capacity increases disproportionately with increased EV adoption as shown in Figure 1. New utility-scale solar capacity represents 18% of all new capacity in the No New EV case, 25% in the Mid EV case, and 35% in the High EV case. This correlation between solar additions and EV adoption reflects how unmanaged EV charging increases load during hours when solar PV output is relatively high – i.e., late afternoon and early evening hours. An assumed Renewable Portfolio Standard (RPS) included in our modeling drove the need for increased renewable generation, and solar PV is a more economic resource that can be used to serve EV charging load than wind generation.

Most of the EV-related changes to investment decisions occurred in the second half of the 2018 to 2030 planning horizon, when EV adoption accelerates. This modeling result suggests there is still time for electric companies to determine how to best incorporate EV forecasts into their system planning efforts.

These findings are sensitive to the assumed resource mix. In an alternative scenario we modeled that assumed a more aggressive RPS, the higher deployment of utility-scale solar generation caused the capacity value of this resource to decline significantly.[2] Under these conditions, wind generation is a more economic resource that can be used to serve EV-related load growth. Further, we note that some jurisdictions with favorable EV economics and policies are likely to reach "threshold" levels of EV adoption significantly faster than others.

EV Managed Charging

We also modeled a "passive" EV managed charging case in which 60% of peak-coincident home EV charging was shifted to after 9 pm. This was done by assuming implementation of a time-of-use (TOU) rate in a manner that is consistent with the impacts achieved in recent voluntary TOU pilot projects. However, for modeling purposes, we assumed all EV customers would be enrolled in the TOU rate (i.e., default deployment) and not just individual who volunteered to do so.

The EV TOU rate reduced the impact of EV charging on system peak demand by roughly 50%. For instance, in the High EV case, the projected EV share of peak demand decreased from 6.6% to 3.2% in 2030. While this impact on the system load profile did not cause a dramatic change the mix of new resource additions in the capacity expansion modeling relative to the scenarios which assumed unmanaged EV charging, it significantly reduced expected total system costs. For our illustrative electric company, passive managed charging is projected to reduce the total cost of serving the additional EV load by 26% over the planning horizon. Cost savings primarily are come from reduced investments in new generation capacity, due to the reduction in system peak demand relative to an unmanaged charging scenario. Figure 2 summarizes the incremental costs of EV load with and without managed charging.

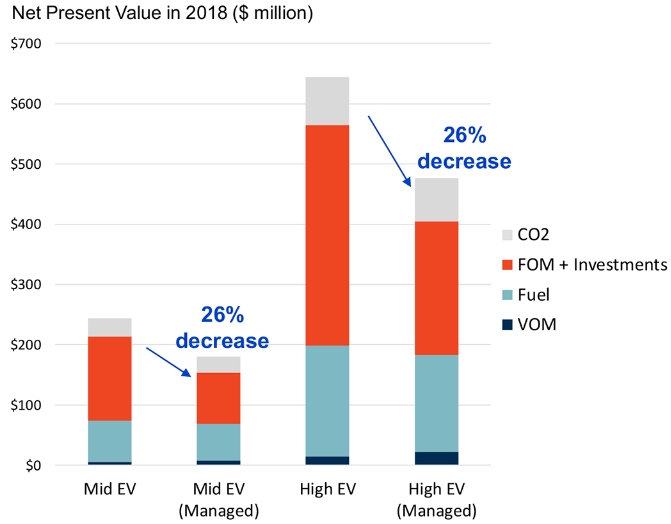

Figure 2: Incremental System Costs Due to EV Adoption Relative to Scenario with No New EVS

Note: The figure illustrates the change in incremental costs in Y-axis with respect to the EV charging scenario shown on the X-axis. In the managed charging cases, 60% of peak-coincident home EV charging was shifted after 9 pm through a time-of-use (TOU) rate.

Conclusion

The modeling conducted for this study shows that EV adoption can significantly impact system planning decisions within a typical planning time horizon. In addition, the modeling results are highly dependent on specific system conditions, particularly generation mix, load shapes, and the use of managed charging. Although consumer EV adoption is accelerating in many parts of the country, electric power system planners may still have a few years to figure out the most appropriate ways to forecast and account for future EV adoption in their long-term resource plans. In addition, the results of this study may encourage electric companies to explore developing and implementing EV managed charging programs (active and passive) in the future.

EPRI Resources

Incorporating Distributed Energy Resources (DERs) into Resource Planning: Solar PV and Electric Vehicles – Annotated Literature Review. EPRI, Palo Alto, CA: 2020. 3002018502

Incorporating DERs into Resource Planning: Exploring the Impacts of Electric Vehicle Adoption on Capacity Expansion Modeling. EPRI, Palo Alto, CA: 2020. 30020200059.

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